

# Science Monstrosity II: Science of the Lambs

Michael Angelo Sorice, Andrew Ullsperger, Sudheer Potru, and Dom Ricci

July 9, 2004

## Tossups

1. A rare mosaic type of this disorder exists where some of the body's cells possess the normal genotype. Risk factors are not completely known, though advanced maternal age seems to play a minor role. Symptoms may include gynecomastia, abnormal body proportions, learning disabilities, and a diminishing of secondary sex characteristics. However, those with the disorder may have few or none of these symptoms, and may only have the most general symptom, infertility. For ten points, name this genetic disorder that occurs in about 1 in every 700 boys, characterized by the genotype XXY.

Answer: **Klinefelter's** syndrome

2. Positron annihilation spectroscopy will often show the defects that give rise to this phenomenon as abnormally deep vacancies, because those defects actually consist of impurities that repel conduction electrons in the solid's lattice structure. This effect arises due to mutual spin flip during electron-impurity scattering, and its namesake's original calculations predicted a divergent resistance as the thermodynamic temperature was decreased to zero, though Anderson renormalization has yielded results in better accord with experiment. For ten points, identify the increase in the resistivity below a certain namesake temperature on the order of 10 K [kelvins] in a crystalline substance with to trapped ferromagnetic impurities, named for a Japanese physicist.

Answer: **Kondo** effect

3. This set of astronomical objects has a peculiar velocity of about 600 km/s [kilometers per second] towards 27 [degrees] right ascension, and it forms a supercluster with the Virgo and Coma clusters, into the former of which it may one day be merged. This is surrounded by many irregular dwarf galaxies, which form its namesake cloud; is approximately 10 million light years in diameter; and is probably in active member exchange with the Maffei 1 group, which lies on the equatorial plane of this group's largest member. For ten points, name the galactic group that includes the galaxies Sextans, Fornax, and Andromeda; both magellanic clouds; and the Milky Way galaxy.

Answer: **local group** of galaxies

4. A facultative anaerobe, this organism can undergo an anaerobic form of respiration that utilizes nitrogen oxides or fumarate as the terminal electron acceptor. While most of the many known strains are harmless, over 700 pathogenic strains of this Gram-negative bacterium are known, and are classified in three major types: enterotoxigenic, enteropathogenic, and the most dangerous, enterohemorrhagic, which is represented by the single serotype O157:H7. For ten points, name this bacterium, a model organism for scientific study and a common resident of the human gut.

Answer: **Escherichia coli**

5. The prototypical one of these point radio emitters was believed to be a star in Lacerta until 1968,

and Oke and Gunn showed that these objects are extra-galactic in 1974, which proves them to be among the most luminous objects in the universe. Many of these objects exhibit superluminal motion, and optically violent variables are particularly spectacular examples of these astronomical objects, of which about two hundred are known. For ten points, name the extremely variable astronomical emitters that are hypothesized to be quasars whose spectra have been altered by gravitational lensing, or quasars-like nuclei with accretion jets pointed more or less directly at the observer.

Answer: blazars

6. First synthesized in 1900, this compound is extremely important in the functioning of joints and tendons, and also helps to maintain and strengthen heart muscle. With an isoelectric point of 6.30, it makes up about 21% of residues in collagen along with its hydroxyl-derivative. Usually synthesized from glutamic acid in most animals, its hydrophobicity contributes to its peculiar structure, which leads to kinks in the peptide chain and in proteins. For ten points, name this nonessential imino acid containing a secondary amine group and ring.

Answer: proline

7. In the monoenergetic spectrum of a small particle detector, this interaction results in a namesake edge and continuum whose shape may be predicted from the Klein-Nishina formula. This is the dominant mode of photon-matter interaction at intermediate energies, and its inverse is sometimes called the Sunyaev-Zel'dovich effect and explains some of the anisotropy of the cosmic microwave background. For ten points, name the phenomenon of incoherent, elastic scattering of a photon by an electron for which the shift in photon wavelength is equal to the namesake wavelength times the quantity one minus the cosine of the scattering angle.

Answer: Compton effect (or Compton scattering or Compton interaction)

8. This often masks the Rashba effect in electron spin interferometers, where it causes oscillatory conductance, and the analogous effect for neutron-nuclei interactions is known as size resonance. This is directly analogous to the transparency of a transmission line nonuniformity to a signal whose wavelength is an integer multiple of the length of the nonuniformity, and it can be explained to first order by examining the probability current transmission coefficient for a rectangular potential well. For ten points, name the effect that may best be defined as the transparency of noble gas atoms to low energy electrons and that is greatest in argon.

Answer: Ramsauer-Townsend effect (or Townsend-Ramsauer effect; do not accept "Townsend effect," which is something else)

9. Products of this chemical reaction often undergo an additional elimination resulting in conjugated systems. Generally using either sodium or potassium hydroxide as a catalyst, it results in an intermediate alkoxide from a nucleophilic enolate's addition to a carbonyl group in either ketones or aldehydes before reaching the final beta-product, which is often altered by dehydration. For ten points, name this condensation reaction whose name combines that of its two final products and which may have been discovered by Aleksandr Borodin.

Answer: aldol condensation

10. This powerful statement may be easily derived from the connectedness of the domain in question, Green's theorem, and its namesake's integral theorem, assuming that the function in question obeys the set of equations named for Riemann and its namesake. Under certain hypotheses, this lemma can be turned on its head to find the leading term of the Laurent expansion of a function singular at  $\infty$  by enclosing all finite point singularities and reversing the conventional direction of integration. For ten points name the theorem that states that the positive closed contour integral of an analytic function with a finite number of isolated singularities is equal to  $2\pi i$  "two pi eye" times the sum of the residues of that function at those

singularities enclosed by the contour.

Answer: Cauchy's residue theorem

11. This is specified by ISO/IEC 14882 and its contents often fail to compile correctly for non-ANSI compilers due to their achievement of genericness via incessant use of templates. This set of classes also contains low-level allocators and utilities such as "Assignable," and it attains generality through decoupling of its member algorithms and iterators from its container classes. For ten points, identify the very useful library of C++ classes that includes vector, list, set, and map among its members and that comes in implementations from HP and SGI.

Answer: standard template library

12. One of the most direct ways to extend this lemma to  $n$  real dimensions involves the impossibility of constructing a continuous locality function, given that a closed, connected region cannot be comprised of two disjoint domains. A modern version may be derived from the connectedness of a function from a connected topological space, given that intervals are the only connected subsets of the real numbers and, though Bolzano is often credited with the first statement of this theorem, his purported proof of it is erroneous. For ten points, name the fundamental mathematical theorem that is equivalent to Rolle's theorem and that was stated by Weierstrass when he noted that a function that is somewhere positive and somewhere negative must vanish at at least one point.

Answer: intermediate value theorem

13. The algorithms of Goldberg and Jenkins are genetic methods for the optimal design of these structures, and triangular ones include the Howe and Fink varieties. Castigliano's theorem may be used to model their ideal deflection given a strain energy, and Hibbler's formula gives the conditions under which one may be statically determinate. The method of sections or that of joints can determine the reactions in the members of these structures, and one is simply supported when one pin and one roller supply the basal external forces. For ten points, identify the fundamental structures from engineering statics comprised of "slender," joined members that can transmit no moments and that are, therefore, fundamentally different from beams.

Answer: trusses

14. Analysis of 16s rRNA has led to the designation of a third group within it; the organisms of this group may be ancestral to the previously known groups. They have histones, use methionine as an initiator amino acid, and have ether-linked lipids. While they share many features on the cellular structure level with bacteria, including a general prokaryotic makeup, analysis of rRNA sequences and subunit binding of polymerases showed them to be more closely related on a molecular level to eukaryotes, a discovery that led to them being accorded a domain of their own name. For ten points, identify this domain of organisms, first classified as such by Carl Woese "WOES", whose members include extremophiles and methanogens.

Answer: Archea or archaeobacteria

15. It begins with oxidative reactions that convert glucose 6-phosphate to ribulose 5-phosphate via an ester and a carboxylic acid intermediate. In the second stage, an isomerase converts the ribulose to ribose. If the ribose produced by the earlier stages is not required, it passes through a series of reactions involving the enzymes transaldolase and transketolase to produce fructose-6-phosphate and glyceraldehyde 3-phosphate for use in glycolysis. While it can provide an alternative metabolic pathway, its primary role is to produce materials for reduction reactions and for nucleic acid synthesis. For ten points, name this series of biochemical reactions that are employed to produce NADPH and five carbon sugars.

Answer: pentose phosphate pathway or pentose shunt

16. It can be derived from dynamical consideration by using the fact that the diffusion constant is equal

to the mobility times the gas constant times the temperature, in which case it also bears Planck's name. It can be more easily derived from thermodynamic considerations by setting the Gibbs free energy to number density times the Faraday constant times the electromotive force. When a system governed by it is in equilibrium, it must satisfy the Donnan relation, and its logarithmic term involves the ratio of the activities of the reduced species to the oxidized species. Relating the actual reversible potential of an electrode to the standard reversible potential of the electrode couple, FTP, identify this electrochemical equation, whose namesake received the Nobel Prize in chemistry for his formulation of the Third Law of Thermodynamics.

Answer: Nernst equation

17. This may be extended to collisional systems by appending to the right hand side an approximation to the collisional partial time derivative of the function in question. This simple-looking statement is necessary to fully characterize the dynamics of the  $\mu$ -space, where the interaction potential cannot be properly defined. This equation may be extended to non-Hamiltonian systems by considering the phase space volume element varies with time as the exponential of the negative of a metric factor. The derivative involved in this theorem can best be understood as the Stokes total time derivative in a phase space. For ten points, name the theorem that conventionally states that Hamiltonian dynamics preserve measure, and that is often given as "the total time derivative of  $\mu$  with respect to  $t$  is zero."

Answer: Liouville's theorem or equation

18. This was characterized by a constant depressed level of atmospheric CO<sub>2</sub> concentrations, and among its effects were the closure of the Hohe Tauern gold mines in the Austrian Alps, a thirty-year long failure of the Faeroe Islands cod fishery beginning in 1675, and the halving of the population of Iceland through famine and disease. While its main phase was contemporaneous with the Maunder Minimum, no actual evidence provides a causal link between it and the paucity in sunspot activity. Immediately preceded by the Medieval Warm Period, the Alaskan Mendenhall Glacier is among its relics. For ten points, what was this modest cooling of the Northern Hemisphere of less than 1C that lasted roughly from the mid-14th to the mid-19th centuries?

Answer: Little Ice Age

19. The disease hereditary angioneurotic edema, caused by a deficiency of C1 inhibitor, can lead to an explosive triggering of this system that can cause anaphylaxis. One of its most important functions is to tag antigens with a protein called opsonin, which causes them to be targeted for phagocytosis. Consisting of about 30 different proteins circulating in blood plasma, this is, for ten points, what part of the immune response involved both in directly attacking antigens and mobilizing defense mechanisms?

Answer: complement

20. This is often considered as a set of three processes, with the isobaric heat rejection in its four-step model replaced with dumping and intake, and a standard ideal cogeneration system combines the Rankine cycle with this. For cold ideal air as the working fluid, this cycle's efficiency varies approximately as its compression ratio to the -0.2857 and, with any ideal gas as the working fluid, it achieves the Carnot efficiency. For ten points, identify the thermodynamic cycle that consists of two isobaric and two isentropic steps, and that is generally used to model gas turbines.

Answer: ideal Brayton cycle (or ideal Joule cycle or ideal Joule-Brayton cycle or ideal Brayton-Joule cycle; prompt on "ideal gas turbine cycle" or "gas turbine cycle" or "ideal turbine cycle" or "turbine cycle")

## Bonuses

1. Answer each of the following about transmission line systems for ten points each.

[10 points] The set of equations known as the transmission line equations give the space-time variation of the transmission line voltage and current and are directly derived from these two equations, given certain realizations about the uniformity of fields within an ideal line.

Answer: **Faraday's law** of induction and **Ampere's law** (accept in either order)

[10 points] This is the fundamental parameter characterizing an ideal transmission line. It is symbolized  $Z_0$  [zee-naught] and defined as the square root of the ratio of the line inductivity to the line capacitvity.

Answer: **characteristic impedance** (prompt on "impedance")

[10 points] This system parameter is generally symbolized  $\Gamma$  [upper-case gamma] and defined as the ratio of the "-" [minus] and "+" [plus] voltage waves at a discontinuity. For a line terminated by its characteristic impedance, this parameter is identically zero.

Answer: voltage **reflection coefficient**

2. Name each of the following somewhat esoteric statistical distributions for ten points.

[10 points] In its general form, this may be given as "emm to the emm times ecks to the emm minus one over gamma of emm times ee to the minus emm ecks" and may be derived to express the statistics of objects obeying its namesake's enumeration theorem.

Answer: **Polya** distribution

[10 points] This distribution gives the probability of a given number of successes in a given number of Poisson trials. The generating function for this distribution is proportional to the 2,1 variety of its namesake function with appropriate parameters.

Answer: **hypergeometric** distribution

[10 points] The gamma distribution is a special case of this distribution, which may be given as "lambda times the quantity lambda ecks to the aych minus one over aych minus one factorial times ee to the minus lambda ecks", in which form it gives the distribution of waiting time for the hth in a series of Poisson events with frequency lambda.

Answer: **Erlang** distribution

3. Answer the following about the structure of bone for the stated number of points.

[ 5 points each] Name the two major types of bone, one type of which makes up the surfaces of bones, while the other forms a porous interior and is the site of most bone formation and resorption.

Answer: **cortical** or **compact** bone and **trabecular** or **cancellous** or **spongy** bone

[10 points] These are thin ducts running through the center of each osteon in cortical bone. They contain blood vessels that supply the bone.

Answer: **Haversian canals**

[10 points] These large, multinucleated cells whose purpose it is to reabsorb matrix hydroxyapatite are paradoxically stimulated by the presence of the similarly named cells whose job it is to lay down new bone.

Answer: **osteoclasts**

4. Identify each of the following from the more mathematical side of computer science for ten points.

[10 points] This important mathematic object consists of a set and a reflexive, anitsymmetric, transitive relation on it. For a set S and relation R, this is often denoted (S,R).

Answer: **partially ordered set** or **poset** [10 points] A poset in which the lexicographical order is such that there exists a least upper bound and greatest lower bound for all pairs of member elements is known as this.

Answer: **lattice** [10 points] These graphs are named for a fascist Marburg professor and represent the minimal specification of a poset. One may be constructed from a digraph of the poset relation by removing the reflection loops, arrows, and edges that must trivially exist due to transitivity, and an experienced viewer

can rapidly pick-off lattices using them.

Answer: **Hasse** diagrams

5. Identify each of the following limits that are only astronomical, not quantum mechanical, for ten points. [10 points] This is the wavelength corresponding to a photon with the energy required to ionize neutral hydrogen, so it is also the minimum photon wavelength for which the interstellar medium is generally transparent. It is equal to approximately 912 angstroms.

Answer: **Lyman** limit [10 points] This is the minimum orbital distance that a stable satellite of a planet may have without being destroyed by gravitational tidal stresses. For bodies of similar composition, this is often cited as about two and a half times the planetary radius.

Answer: **Roche** limit [10 points] This is an estimate of the density of the local disk, and is currently about .15 solar masses per parsec cubed. Current efforts to find better values involve epicyclic motion of K class giants and hope to give a better understanding of the nature of dark matter.

Answer: **Oort** limit

6. Identify each of the following graphical devices employed by scientists for ten points.

[10 points] This great aid for electrical engineers allows matching of line parameters and was introduced by its namesake in 1939. It is a mapping of the interior of a complex unit circle onto the complex normalized impedance of a line.

Answer: **Smith** chart

[10 points] This is a semilog plot of Darcy friction factor as a function of Reynolds number, with pipe roughness as a parameter. It was introduced by its namesake fluid mechanist in 1944 to graphically present the observations Poisselle [pwah-ZAY], Nikuradse [nick-uh-RUDE-zeh], Colebrook, and others.

Answer: **Moody** diagram

[10 points] This is a state-indicating graph of various properties as a function of specific enthalpy and entropy, which are on the vertical and horizontal axes respectively, so it is also known as an h-s diagram. That for water is published particularly often to aid thermodynamicists everywhere.

Answer: **Mollier** diagram

7. Answer the following about lipids, for ten points each.

[10 points] These lipids are the primary constituent of dietary fats and oils, and consist of a propane-1,2,3-triol molecule bound by ester linkages to three fatty acids.

Answer: **triglycerides** or **triacylglycerols**

[10 points] These are a class of glycolipids where a single sugar unit, usually galactose, is bound to a sphingolipid. As their name implies, they are often found in the plasma membranes of neurons, and are especially abundant in myelin sheaths.

Answer: **cerberosides**

[10 points] A common linkage between membrane lipids and surface proteins, this is an anchor composed of a sugar bridge connecting the C-terminus of a protein to a particular membrane lipid.

Answer: **GPI** anchor (glycosyl-phosphatidylinositol) or **PIG** anchor (phosphatidylinositol glycosylate)

8. Answer each of the following related items from fluid mechanics for ten points.

[10 points] This was first published in 1752 and states, in essence, that inviscid theory predicts no drag for any body whatsoever in a uniform stream, which prediction is badly out of accord with experimental results.

Answer: **d’Alambert’s paradox**

[10 points] D’Alambert’s paradox led to a near wholesale rejection of inviscid theory until 1904, when this Gttingen professor published his seminal ”ber Flssigkeitsbewegung bei sehr kleiner Reibung.” This physicist is the namesake of a wing theory with Lanchester and of a rule for subsonic airflow with Glaubert.

Answer: Ludwig **Prandtl**

[10 points] Prandtl's 1904 paper introduced this region near a no-slip surface in which region viscous effects are important. The thickness of this region is generally symbolized with a lower case delta, and inviscid theory is valid outside of it, which fact allows for "patched" complete descriptions of fluid flows.

Answer: boundary layer (or shear layer; do not accept "wall layer" or "overlap layer.")

9. Answer each of the following on atmospheric phenomena for ten points.

[10 points] This is defined as the height at which the atmosphere can be considered "well-mixed" and is defined by equating the eddy diffusion and molecular diffusion coefficients. Above it, heavier species are depleted in its namesake "effect."

Answer: homopause

[10 points] This fundamental nondimensional parameter governs natural atmospheric convection. Like the similar Rayleigh number, this may be abstractly defined as the ratio of the effects of buoyancy to those of viscosity.

Answer: Grashof number

[10 points] This is the term for the thermal ejection of atmospheric constituents due to the random achievement of escape velocity. Though it is generally negligible for planetary atmospheres, it does noticeably shift the distribution of very light gasses in the Earth's upper atmosphere.

Answer: Jeans escape

10. Answer each of the following about your friend and mine, NMR, for ten points.

[10 points] NMR can best be understood in terms of the precession of this vector, symbolized M. This macroscopic property is classical equal to the product of the magnetic dipole density and moment, and its curl is equal to the induced bound current density.

Answer: magnetization [10 points] The precession of the magnetization can itself be understood in terms of this theorem, which states that the time derivative of the expectation value of an observable is equal to the expectation value of the partial time derivative of that observable's operator plus  $i/\hbar$  "eye by aychbar" times the expectation value of the commutator of the Hamiltonian operator with that observable operator.

Answer: Ehrenfest's theorem (or Ehrenfest's principle)

[10 points] The primary precession of the magnetization in NMR occurs with this circular frequency, which is equal to the product of the electron gyromagnetic ratio and the magnitude of the main, uniform magnetic field.

Answer: circular Larmor frequency (or Larmor circular frequency)

11. Identify each of the following rules from quantum mechanics for ten points.

[10 points] These are a set of related equations giving the asymptotic transition probabilities per unit time for a variety of different situations. The first of these gives the transition frequency for the case of a constant perturbing operator.

Answer: Fermi's golden rules

[10 points] These are a number of conditions stating that a variety of action integrals are equal to integer or half-integer multiples of Planck's constant. The first of these, which is conventionally stated as "the closed path integral of pee dot dee queue equals enn aych" is used in its first namesake's model of the hydrogen atom.

Answer: Bohr-Sommerfeld quantization rules (or Bohr-Sommerfeld quantization conditions)

[10 points] These are any number of proscriptions dictating which transitions or decays are "allowed" and which "forbidden," and are generally the application of conservation laws to quantum number changes via first order perturbation theory.

Answer: selection rules

12. Identify the following about hydrological movement for ten points each.

[10 points] This 65-80 year cycle with an 0.4 degree variation in the mean water temperature has been observed in its namesake ocean and has a positive correlation with a similar variation in the Pacific. During its warmings, the U.S. experiences reduced rainfall, as in the Midwest droughts of the 1930s.

Answer: Atlantic Multidecadal Oscillation

[10 points] In this prevalent type of hydrologic transport named for a Swedish oceanographer the wind stress on a layer of surface water is balanced by the Coriolis and frictional forces, thus resulting in convergence and divergence regions.

Answer: Ekman transport

[10 points] This term denotes a full cycle formed by the confluence of several oceanic surface currents. The North Atlantic one is composed of the North Equatorial Current, the Gulf Stream, the North Atlantic Current, and the Canary Current.

Answer: gyre

13. Name these solvents commonly used in organic chemistry from clues, for ten points each.

[10 points] This cyclic ether is often used in place of diethyl ether as a solvent, as many compounds are more soluble in it, and it is far less volatile.

Answer: tetrahydrofuran or THF

[10 points] This sulfur-containing solvent is widely used, and also finds use as a reagent in important oxidation reactions. While not highly toxic itself, it is readily absorbed through the skin, taking solutes with it.

Answer: dimethyl sulfoxide or DMSO

[10 points] This extremely polar and extremely toxic aprotic phosphorus-containing substance is often used as a solvent for organolithium compounds.

Answer: HMPA or hexamethylphosphoramide

14. Identify each of the following about some things that are preventing you all from dying right now for the stated number of points.

[5 points] These are generally cylindrical, neutron-absorbing assemblies whose motions have an effect on the reactivity of a nuclear fission reactor. These come in "grey" and "black" varieties and central ones may have reactivity worths on the order of several cents.

Answer: control rods

[15 points] The injection of these is the most common mechanism for controlling nuclear reactivity other than use of control rods. These are absorbing solutes with highly controllable concentrations in the reactor water supply, and they change the reactivity by altering the thermal utilization.

Answer: chemical shims

[10 points] The third mechanism of reactor control consists of the use of these substances, which are created naturally as reaction byproducts and include xenon-135 and samarium-149. Burnable ones may be included in the initial fuel to increase the net power extracted over the fuel lifetime.

Answer: poisons

15. Answer the following about types of plant tissues, for ten points each.

[10 points] This supporting tissue is made up of elongated cells with secondary cell walls impregnated with lignin, and is dead at maturity.

Answer: sclerenchyma

[10 points] In contrast to sclerenchyma, cells of this supporting tissue found mainly in leaves and stems are alive at maturity, and cell walls do not contain lignin.

Answer: collenchyma

[10 points] This vascular tissue is distinguished by the presence of sieve element cells and the companion cells that support them, and transports the products of photosynthesis.

Answer: **phloem**

16. For ten points each, name these hormones important in giving birth.

[10 points] This steroid hormone is produced primarily by the corpus luteum, but is also made by the placenta. It is principally responsible for preparing the endometrium to accept a fertilized egg.

Answer: **progesterone** [10 points] This peptide hormone produced by the posterior pituitary stimulates uterine contractions at the time of birth; following birth, it stimulates release of milk. A synthetic form is administered to induce labor.

Answer: **oxytocin** [10 points] This peptide hormone with a structure similar to insulin softens the cervix and pelvic ligaments, making it easier for the fetus to pass through the birth canal.

Answer: **relaxin**

17. Name these properties of mixtures, for ten points each.

[10 points] This is a point on a phase diagram that corresponds to a composition of a mixture that has the lowest melting or freezing point.

Answer: **eutectic** point

[10 points] This is a mixture of two or more components that has a constant boiling point at a particular composition, making further separation by distillation alone impossible. Examples include 95% ethanol in water.

Answer: **azeotrope**

[10 points] This characteristic, defined as a partial molar Gibbs free energy and usually symbolized by  $\mu$ , is very important in the thermodynamics of mixing and solution.

Answer: **chemical potential** (accept Fermi energy)

18. Answer the following about the chemistry of esters, for ten points each.

[10 points] This named reaction, a staple of organic chemistry lab courses everywhere, produces an ester by combining a carboxylic acid with an alcohol in the presence of heat and catalytic acid.

Answer: **Fischer esterification**

[10 points] This is the term for a cyclic ester. They are often prepared by Baeyer-Villiger oxidation of cyclic ketones.

Answer: **lactones**

[10 points] These compounds, useful as sedatives, can be produced by nucleophilic substitution reactions between malonic ester derivatives and urea. They were first synthesized in 1864 by Baeyer.

Answer: **barbiturates**

19. Answer each of the following about a certain formulation of classical mechanics for the ten points.

[10 points] In its most general form, this principle states that the variation of the action functional vanishes. It is the foundation for its namesake's formulation of classical mechanics.

Answer: **Hamilton's** principle (do not accept "principle of least action" for several reasons, the chief of which is, whomever "least action" is does not have a formulation of classical mechanics.)

[10 points] Variational methods are used to derive this set of differential equations which, if a particle trajectory satisfies, it necessarily satisfies Hamilton's principle. For the  $i$ th degree of freedom, these take the form "partial  $\mathcal{L}$  with respect to  $x_i$  minus  $d/dt$  of partial  $\mathcal{L}$  with respect to  $\dot{x}_i$  equals zero" where  $x_i$  is the  $i$ th spatial coordinate, its time derivative, and  $\mathcal{L}$  an appropriate energy function.

Answer: **Euler-Lagrange** differential equations (or Lagrange-Euler differential equations or Euler's differential equations or Lagrange's differential equations)

[10 points] This equation is related to the Euler-Lagrange equations, and is derived from the preservation of Hamilton's equations by a canonical transform. This equation states that the sum of the time partial derivative of a canonical generating function and the Hamiltonian with conjugate momenta stated in terms

of the spatial derivatives of that generating function vanishes.

Answer: **Hamilton-Jacobi** equation

20. Name these delicious parts of the brain, for ten points each.

[10 points] This is the band of nerve fibers connecting the medulla and cerebellum to the midbrain.

Answer: **pons Varolii**

[10 points] This group of regions of the brain that includes the hippocampus and hypothalamus is involved in expression of mood and instinct, and plays a major role in long-term memory.

Answer: **limbic system**

[10 points] These clusters of serotonergic neurons lie on either side of the brainstem and play an essential role in the sleep and wake cycle. Damage to them can cause either insomnia or permanent coma.

Answer: **raphe nuclei**